

METHOD FOR FABRICATING AN ANTI-GLARE PIXEL-DEFINING LAYER ON AN OLED PANEL

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to a surface treatment process for fabricating a panel of an organic light emitting device (OLED), particularly to a surface treatment process for fabricating an anti-glare pixel-defining layer on a panel of an OLED.

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2. Description of Related Art

The latest OLED dominated a focus of developing flat panel display (FPD) technology in recent years. Compared with other FPDs such as LCDs (liquid crystal displays) and FEDs (Field emission
15 displays), OLED display panels have many distinguished advantages such as light weight, high contrast, fast response rate, low power consumption and high brightness. Although many benefits can be found in the OLED display panels, lots of technical problems in manufacturing OLED display panels still need to be overcome.

20 So far, the fabrication of OLED display panels is achieved by subsequently forming anode in parallel stripes, parallel photoresist ramparts, organic electroluminescent media and cathodes on the substrate of panels. The parallel photoresist ramparts acts as shadow masks as organic electroluminescent media and cathode materials are
25 deposited on the exposed parallel anodes between photoresist ramparts.

Although the OLED made by the conventional process can adopt as a display, the contrast and the quality of display is limited. In most cases, the contrast of the OLED panels is decreased by or interfered with the ambient light . To improve the contrast of the OLED panels, the application of polarizers is proposed. However, although the polarizer can decrease the interference of the environmental light and increase the contrast of display, the polarizer also decrease the brightness of the OLED panel. This side effect is owing to the emission-light absorption of the polarizers themselves. For a flat panel display with polarizers attached on both planes, only 38 % of the injecting light can pass through the flat panel display with polarizers. Therefore, the conventional polarizers cannot provide a solution for increasing the contrast of the OLED panels without absorption issues and reduce the glare interference of the ambient light.

On the other hand, the lifetime of the OLED panels produced by conventional manufacturing process is not long. The stability of the OLED displays and the yields of these manufacturing processes are poor. The short lifetime and the poor stability of the OLED display panels is resulted from direct contact between anodes and cathode materials in areas close to the border of pixels or the area close to the bottom of the sidewalls of photoresist ramparts. Since the border of pixels are only roughly defined or separated by the photoresist ramparts and the anodes on the substrate, the contact between anodes and cathode materials cannot be effectively prevented. Therefore, the OLED display panels

need an effective method to prevent the opportunity of electrical shorts between anodes and cathodes.

Recently, insulation layers made by photoresist are suggested to coated on the surface of the substrate to prevent possible electrical shorts.

5 However, since the insulation layer made by photoresist around pixels' areas keep releasing organic solvent or water vapor in the OLED slowly, the photoresist insulation layers become major sources of vapors to deteriorate the quality of the sensitive organic electroluminescent media on the OLED display panel. Therefore, the photoresist insulation layers
10 also are the major factor causing short lifetime and poor display quality. Moreover, the photoresists contain many photosensitive chemicals which decrease the photochemical stability of the photoresist insulation layers under high emission and decreased the lifetime of the OLED display panels. In this condition, the photoresist insulation layer is not a right
15 answer to solve the problem illustrated above. Therefore, a method for fabricating a pixel-defining layer on the OLED panel to provide high yield in manufacturing process, good stability of pixel-defining layers for preventing electrical shorts and extending the lifetime of pixels or OLED display panels are urgently in demand.

20 Therefore, it is desirable to provide an improved method to mitigate the aforementioned problems.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method for
25 fabricating an anti-glare pixel-defining layer on an OLED panel to absorb

and filter the ambient light from environment to reduce interference, increase the effectiveness of light emission of the OLED panel, and increase the anti-glare function of the OLED panels.

Another object of the present invention is to provide a method for
5 fabricating an anti-glare pixel-defining layer on an OLED panel to clearly define the area of the pixels on said OLED panel and to separate cathodes from anodes for avoiding shorts.

Another object of the present invention is to provide a method for fabricating an anti-glare pixel-defining layer on an OLED panel for the
10 application in the continuous mass-production of big OLED panels.

To achieve the objects, the method for fabricating an anti-glare pixel-defining layer of the present invention includes:

- (A) providing a substrate;
- (B) forming a plurality of first electrodes on said substrate;
- 15 (C) coating a layer of anti-glare compositions comprising at least
 - (1) non-photosensitive polyimide or polyimide precursor and
 - (2) light-absorbing pigments or dyes on said substrate or selectively on said first electrodes;
- (D) first prebaking said substrate with said layer of said anti-glare
20 compositions;
- (E) coating a layer of photoresist compositions on said layer of anti-glare compositions;
- (F) second prebaking said substrate with said anti-glare compositions and said photoresist;
- 25 (G) forming patterns of said photoresist through exposing said

substrate to masked radiation, developing said photoresist on said substrate, etching said layer of said anti-glare compositions and said photoresist at the same time to form patterned layers of said anti-glare polyimide or polyimide precursor compositions and patterned photoresist; wherein
5 said patterns of said photoresist are as same as said patterns of said layers of said anti-glare polyimide or polyimide precursor compositions;

(H) releasing or stripping said photoresist; and

10 (I) baking said substrate with said patterned anti-glare polyimide or polyimide precursor compositions for crosslinking or curing said patterned anti-glare polyimide or polyimide precursor compositions to form said anti-glare pixel-defining layers;

15 wherein said patterns of said layer of said anti-glare polyimide or polyimide precursor compositions divide said first electrodes into a plurality of open areas which are not covered by said anti-glare pixel-defining layers.

The method for forming an anti-glare pixel-defining layer on an
20 OLED panel of the present invention can further includes: (J) forming a plurality of photoresist ramparts on said substrate and selectively on said first electrodes or said stripes of said polyimide pixel-defining layer; wherein said photoresist ramparts protrude from said substrate and the top sections of said ramparts are about parallel to the surface of said
25 substrate.

The method for forming an anti-glare pixel-defining layer on an OLED panel of the present invention can further includes: (K) depositing organic electroluminescent media to the exposed area between said ramparts on said substrate or said first electrodes; and (L) forming a plurality of second electrodes on said organic electroluminescent media on said substrate or said first electrodes.

The method for forming an anti-glare pixel-defining layer on an OLED panel of the present invention can selectively further comprising forming a plurality of auxiliary electrodes on or beneath the surface of said substrate before forming a plurality of said first electrodes on said substrate.

The method for forming an anti-glare pixel-defining layer on an OLED panel of the present invention can selectively further comprising forming parallel photoresist ramparts having T-shape cross-section on said non-photosensitive polyimide pixel-defining layer, and said patterns of said photoresist are parallel stripes.

The OLED panel of the present invention comprises: a substrate; a plurality of first electrodes in parallel stripes, said first electrodes locating on the surface of said substrate; a plurality of anti-glare polyimide pixel-defining layers, said anti-glare polyimide pixel-defining layers selectively locating on said substrate or on said first electrodes, and said anti-glare polyimide pixel-defining layers comprising at least (1) non-photosensitive polyimide or polyimide precursor and (2) light-absorbing pigments or dyes; a plurality of photoresist ramparts, said photoresist ramparts selectively locating on said first electrodes or on

said pixel-defining layer; a plurality of organic electroluminescent media, said organic electroluminescent media locating in the exposed area between said ramparts on said substrate; and a plurality of second electrodes, said second electrodes locating on said organic electroluminescent media; wherein each said ramparts protruding from said substrate and having an overhanging portion projection in a direction parallel to said substrate; and said photoresist ramparts are formed through coating a compositions of photoresist on said substrate, exposing said substrate to masked radiation and development.

Other objects, advantages, and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially enlarged perspective view of the panel of the present invention before formation of organic electroluminescent medium and cathodes (second electrodes);

FIG. 2 is a photograph from the top view of the OLED panel of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The method of the invention for forming an anti-glare pixel-defining layer on an OLED panel, comprising following steps: (A) providing a substrate; (B) forming a plurality of first electrodes on said substrate; (C) coating a layer of anti-glare compositions comprising at

least (1) non-photosensitive polyimide or polyimide precursor and (2) light-absorbing pigments or dyes on said substrate or selectively on said first electrodes; (D) first prebaking said substrate with said layer of said anti-glare compositions; (E) coating a layer of photoresist compositions on said layer of anti-glare compositions; (F) second prebaking said substrate with said anti-glare compositions and said photoresist; (G) forming patterns of said photoresist through exposing said substrate to masked radiation, developing said photoresist on said substrate, etching said layer of said anti-glare compositions and said photoresist at the same time to form patterned layers of said anti-glare polyimide or polyimide precursor compositions and patterned photoresist; wherein said patterns of said photoresist are as same as said patterns of said layers of said anti-glare polyimide or polyimide precursor compositions; (H) releasing or stripping said photoresist; and (I) baking said substrate with said patterned anti-glare polyimide or polyimide precursor compositions for crosslinking or curing said patterned anti-glare polyimide or polyimide precursor compositions to form said anti-glare pixel-defining layers; wherein said patterns of said layer of said anti-glare polyimide or polyimide precursor compositions divide said first electrodes into a plurality of open areas which are not covered by said anti-glare pixel-defining layers.

Since polyimides have better thermal, electrical, mechanical and photochemical stability than other conventional polymers for insulation, polyimides are good candidates for pixel-defining layers. On the other hand, the cured polyimides hardly release organic solvent to deteriorate

the sensitive organic electroluminescent media of OLED panels. This advantage can extend the lifetime of the OLED panel. Moreover, the polyimide pixel-defining layers on the OLED panels of the present invention can separate the ITO anodes and the cathodes effectively from electrical shorts. By way of clear defining the pixel area and fully separating the anodes and the cathode materials, the polyimide pixel-defining layers can decrease the opportunity of shorts between anodes and the cathode materials, especially the cathode materials deposited close to the bottom of the sidewalls of the photoresist ramparts, on the OLED panels. Therefore, the yield of producing OLED panels can increase significantly. Furthermore, since the anti-glare polyimide pixel-defining layer of the present invention can absorb the ambient light effectively, the interference and the glare effect caused by the injected light from environments will be greatly reduced.

The substrate that applied in the process of the present invention can be transparent or not transparent. Preferably, the substrates used in the present invention are sodalime glasses, boron silica glasses, plastics or silicon wafers. The anode suitable for the present invention can be any conventional material for electrical conductance. Preferably, the first electrode (anode) of the present invention can be InSnO_3 , SnO_2 , In_2O_3 doped with ZnO , CdSnO or antimony. The second electrode (cathode) suitable for the present invention can be any conventional material for electrical conductance. Preferably, the second electrode (cathode) of the present invention can be MgAg , Al , BaAl , dimonds, like-dimond or Ca .

For the method for forming a anti-glare pixel-defining layer of

the present invention, a plurality of parallel auxiliary electrodes can be selectively formed on the substrate before the anodes are formed for providing better electrical conductance for first electrodes (anodes). In most cases, the parallel auxiliary electrodes form through lithography on the substrate. The materials of the auxiliary electrodes are not limited. Any conventional materials for electrical conductance can be used. Preferably, the auxiliary electrode is Cr, Al, Cu, Ag or gold. The anti-glare polyimide can be coated on the substrate through any conventional method. Preferably, the anti-glare polyimide or polyimide precursor compositions is coated through spin-coating on the substrate. The substrate coated with anti-glare polyimides or polyimide precursor compositions is first prebaked at a temperature to drive out the solvent inside the non-photosensitive polyimides or polyimide precursor compositions. Preferably, the coated substrate is first prebaked at a temperature ranging from 120 to 160 °C. The prebaked anti-glare polyimide or polyimide precursor compositions is then coated with a layer of photoresist. Preferably, the photoresist is positive photoresist. Most preferably, the photoresist is AZ-TFP650. The photoresist can be coated on the substrate through any conventional method. Preferably, the photoresist is coated through spin-coating of on the substrate. The substrate coated with photoresist is second prebaked at a temperature to drive out the solvent inside the photoresist. Preferably, the coated substrate is second prebaked at a temperature ranging from 90 to 110 °C. The substrate coated both photoresist and anti-glare photosensitive polyimide or polyimide precursor compositions can be exposed to

masked radiation and developed to form patterns. The development of the photoresist can be achieved by any conventional method and chemical. Preferably, the photoresist is developed by 2.38 % of TMAH (tetramethyl ammonium hydroxide). The pattern of the photoresist is not limited. Preferably, the pattern of the photoresist is parallel stripes intersecting anodes perpendicularly or a stripe net with selective open portion areas on the first electrodes (anodes) on the substrate. The anti-glare polyimide or polyimide precursor compositions is then etched to form a pattern as same as that of the photoresist. The formation of the pattern of anti-glare polyimide or polyimide precursor compositions can be achieved by any conventional etching method (such as dry etching or wet etching) or etching reagents. Preferably, the anti-glare polyimide or polyimide precursor compositions are etched by wet etching. Most preferably, the anti-glare polyimide or polyimide precursor compositions are etched by a solution of 2.38 % of TMAH (tetramethyl ammonium hydroxide). The patterned photoresist is then released or stripped after the patterned anti-glare polyimide or polyimide precursor compositions is etched. Preferably, the photoresist is released or stripped by isopropanol, PGMEA or n-butyl acetate. The patterned anti-glare polyimide or polyimide precursor compositions can be baked at a temperature that the non-photosensitive polyimides or polyimide precursor compositions can crosslink or cure to form an anti-glare pixel-defining layer. Preferably, the baking temperature is at least higher than 200 °C. The non-photosensitive polyimides or polyimide precursor compositions applied in the method of the present invention can be any

conventional non-photosensitive polyimides or polyimide precursor compositions. Preferably, the non-photosensitive polyimides or polyimide precursor compositions contains polyamic acids reacted from amines such as ODAs (oxydianiline) and anhydrides such as PMDAs (pyromellitic dianhydride) or polyamic acid reacted from amines such as ODA (oxydianiline) and anhydrides such as BTDA (benzophenone tetracarboxylic dianhydride) or PMDAs (pyromellitic dianhydride). The light absorbing pigments or dyes of the anti-glare polyimide compositions of the present invention can be any conventional light absorbing pigments or dyes. Preferably, the light absorbing pigments or dyes are black light absorbing pigments or dyes.

After the anti-glare pixel-defining layers form, the process for forming organic electroluminescent media and the cathodes of the OLED panels can be achieved subsequently. A plurality of photoresist ramparts form on the substrate with anti-glare polyimide pixel-defining layer through photolithography. The patterns of the photoresist ramparts are not limited. Preferably, the photoresist ramparts are parallel ramparts and have T-shape cross-section. The photoresist ramparts selectively intersect with the anodes and the pixel defining layers. Preferably, the photoresist ramparts selectively intersect with the anodes perpendicularly. The photoresist can be any conventional photoresist. Preferably, the photoresist ramparts are made of positive photoresist. Most preferably, the photoresist ramparts on the panel of the OLEDs are made of positive chemically amplified photoresist compositions that contain photo-acid generators. The ramparts on the substrate of the panels of OLEDs act as

ideal shadow masks for subsequent deposition processes and also serves as isolating walls to separate side-deposited cathode materials from anodes.

Organic electroluminescent media are formed after a plurality of first electrodes (anodes) and ramparts are formed. The organic electroluminescent media are deposited on the substrate and selectively on anodes. The organic electroluminescent media are deposited as a single layer or optionally multiple layers (e.g. hole transporting layers, emitting layers, electron transporting layers) on the substrate and selectively on anodes. A plurality of cathodes (second electrodes) then form on the organic electroluminescent media on the substrate. The formation of cathodes (second electrodes) can be achieved through conventional deposition methods. The organic electroluminescent media is sandwiched by cathodes (second electrodes) and the anodes (first electrodes) on the substrate. The open portions where anodes (first electrodes) and cathodes (second electrodes) locate between ramparts are the emitting portions (i.e. pixels) of OLED. The projections of the first electrodes on the substrate intersect those of the second electrodes. Preferably, the projections of the first electrodes (anodes) are perpendicular to the projections of the second electrodes.

Figure 1 is a partially enlarged perspective view of the panel of the present invention before formation of organic electroluminescent medium and cathodes (second electrodes). A plurality of auxiliary electrodes 70 is formed on the substrate 10 in parallel stripes through photolithography. Then a plurality of anodes (first electrodes) 20 is

formed in parallel stripes on the substrate 10. The anodes (first electrodes) 20 are almost in the same height and each first electrode cover two auxiliary electrodes 70. An anti-glare pixel-defining layer 60 in a pattern of multiple pixel windows is formed on the substrate 10 and first electrodes 20 subsequently. The open windows of the anti-glare pixel-defining layer 60 locate above part of the anodes (first electrodes) 20. Each stripe of the anodes (first electrodes) 20 is separated into several open areas by the anti-glare pixel-defining layer 60.

The formation of anti-glare pixel-defining layer 60 is achieved by first spin coating a composition of non-photosensitive polyimide precursors on the substrate where the auxiliary electrodes and anodes (first electrodes) 20 locate. The coated substrate is first prebaked to drive out the solvent inside the non-photosensitive polyimide composition. Then a layer of positive photoresist is coated on the non-photosensitive polyimide. A patterned photoresist and a non-photosensitive polyimide composition layer with identical patterns further forms through photolithography. The patterned photoresist is then stripped or released. The non-photosensitive polyimide composition layer is further cured and crosslinked to form an anti-glare pixel-defining layer on the substrate.

A plurality of ramparts 50 which protrude on the substrate 10 and have T-shape cross-section is formed on the anti-glare pixel-defining layer 60 and the substrate 10. The ramparts 50 have an overhanging portion projecting in a direction parallel to the substrate 10. The ramparts 50 are in a pattern of parallel strides and cross over the first electrodes 20 perpendicularly. The open portions between ramparts 50 are above the

open window areas of anti-glare pixel-defining layer 60. The open window areas of anti-glare pixel-defining layer 60 are the locations of future pixels after subsequent organic electroluminescent media 30 and second electrodes 40 form.

5 The OLED panels made through the methods illustrated above can be further processed to selectively form an anti-reflection layer on the panel or to be sealed by a cover. The color of the pixels of the OLED panels through the methods of the present invention can be any conventional colors such as red, green or blue. The color of the pixels of
10 the OLED panels can be controlled by the organic electroluminescent media. The OLED panels of the present invention can be either panels with single color, multiple colors or full colors.

 The OLEDs achieved through the method of the present invention can be applied to any display of images, graphs, symbols,
15 letters and characters for any apparatus. Preferably, the OLEDs of the present invention are applied to the display of televisions, computers, printers, screens, vehicles, signal machines, communication devices, telephones, lights, electronic books, microdisplays, fishing machines, personal digital assistants (PDA), game machines, game goggles and
20 airplanes.

 More detailed examples are used to illustrate the present invention, and these examples are used to explain the present invention. The examples below, which are given simply by way of illustration, must not be taken to limit the scope of the invention.
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Example 1

A panel of an OLED was fabricated through the surface treatment process of the present invention.

A clean glass substrate deposited with a layer of Cr and a layer of ITO was applied here. The auxiliary Cr electrodes in parallel stripes were formed through photolithography. After the substrate with auxiliary Cr electrodes was fully cleaned, ITO anodes were formed in a pattern of stripes on the cleaned glass substrate. Each ITO stripe was coordinated with two auxiliary electrodes on the surface of the ITO stripe. Then the substrate was spin-coated with a solution of adhesion promoter (APX) and anti-glare polyimide composition (DARK 400) at a spin rate ranging from 1000 to 3000 rpm. The coated substrate was first prebaked in an oven at 100 °C and then at 145 °C. The substrate was spin coated with another solution of positive photoresist (AZ TFP650) at a spin rate ranging from 2000 to 4000 rpm. The substrate coated with positive photoresist and anti-glare polyimide was then second prebaked at a temperature of 100 °C. A mask with a pattern having rectangular open portions is applied as the coated photoresist was exposed to radiation. The coated substrate was developed. The development was finished by spraying 2.38 % of tetramethyl ammonium hydroxide solution on the exposed substrate to form a layer of photoresist having a pattern with rectangular open portions. The anti-glare polyimide was then etched by a solution of 2.38 % of tetramethyl ammonium hydroxide to form a layer of polyimide with a pattern as same as that of the photoresist. The photoresist layer was then stripped or released by isopropanol, PGMEA or butyl acetate. The substrate was cured at a temperature of 230 °C in an oven to form a non-photosensitive polyimide anti-glare pixel-defining layer on the substrate.(as shown in Fig.2)

Then a positive chemically amplified photoresist (APEX resist from

Shipley corp.) composition was spin-coated on the substrate. The coated substrate was prebaked in ovens at a temperature ranging from 90 to 110 °C. A mask with a pattern in stripes was applied as the coated photoresist was exposed to radiation (deep UV). The exposed substrate was

5 post-exposure baked and treated with TMAH atmosphere at the same time. Ramparts of photoresist are formed in a parallel-stripe pattern. The stripes of the ramparts formed are also perpendicular to the stripes of ITO. The ramparts formed on the substrate have T-shape cross-section. The width of ramparts stripes is about 0.18 μm and the height of ramparts is about 0.8
10 μm . Then the exposed portions between ramparts are deposited by TPD (N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine) at a 700 Å thickness. Subsequently, Alq₃ is deposited on the same area at a 500 Å thickness. MgAg was deposited on the same area at a 1000 Å thickness to form a panel of an OLED .

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Although the present invention has been explained in relation to its preferred embodiment, it is to be understood that many other possible modifications and variations can be made without departing from the spirit and scope of the invention as hereinafter claimed.

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